



US009151493B2

(12) **United States Patent**  
**Adam et al.**

(10) **Patent No.:** **US 9,151,493 B2**  
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **COAL ROPE DISTRIBUTOR WITH  
REPLACEABLE WEAR COMPONENTS**

(75) Inventors: **Daniel J. Adam**, East Canaan, CT (US);  
**Oliver G. Briggs, Jr.**, Jefferson, MA  
(US); **Thomas J. Campanelli**, Berlin,  
CT (US); **Paul M. Colson**, Southwick,  
MA (US); **Christopher D. Curl**,  
Branford, CT (US); **Dai Q. Dau**,  
Hartford, CT (US); **Wendell H. Mills**,  
Granby, CT (US)

(73) Assignee: **ALSTOM Technology Ltd**, Baden (CH)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 1281 days.

(21) Appl. No.: **12/504,932**

(22) Filed: **Jul. 17, 2009**

(65) **Prior Publication Data**

US 2010/0154688 A1 Jun. 24, 2010

**Related U.S. Application Data**

(60) Provisional application No. 61/138,578, filed on Dec.  
18, 2008.

(51) **Int. Cl.**  
**F23D 1/00** (2006.01)  
**F23K 3/02** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC .. **F23D 1/00** (2013.01); **F15D 1/04** (2013.01);  
**F23K 3/02** (2013.01); **F23M 11/042** (2013.01);  
(Continued)

(58) **Field of Classification Search**  
CPC ..... F23K 3/02; F23K 2203/008; F23K  
2203/201; F23D 2201/20; F23C 7/008  
USPC ..... 285/179; 403/205; 110/104 B, 263  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,055,416 A \* 9/1962 Marshall ..... 431/59  
4,027,605 A 6/1977 Legille

(Continued)

**FOREIGN PATENT DOCUMENTS**

CN 2051324 U 1/1990  
CN 101135444 3/2008

(Continued)

**OTHER PUBLICATIONS**

PCT International Search Report and The Written Opinion of the  
International Searching Authority dated Nov. 20, 2009—(PCT/  
US2009/065273).

(Continued)

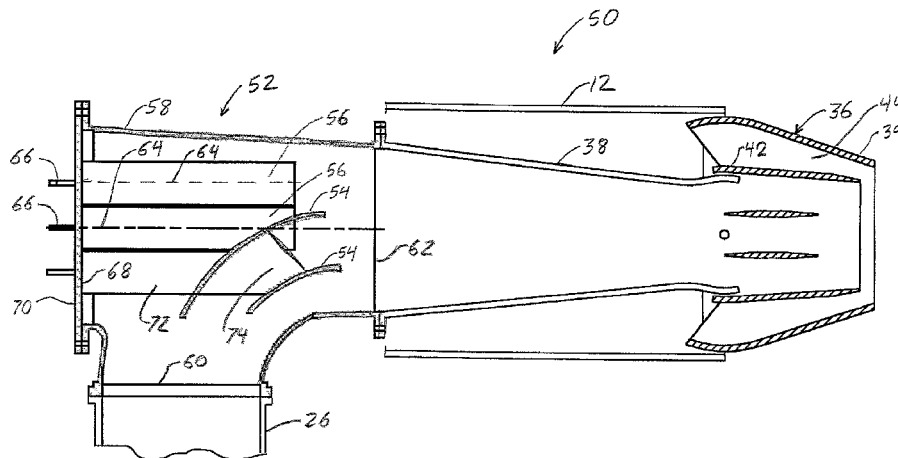
*Primary Examiner* — David J Laux

(74) *Attorney, Agent, or Firm* — Robert D. Crawford

(57) **ABSTRACT**

A head assembly **52,152** for a pulverized coal nozzle includes a turning vane **54** or a curved vane **154** disposed within a pipe elbow. The vanes **54,154** are angled relative to the inlet port and the outlet port of the pipe elbow to redirect a stream of air and pulverized solid fuel particles from the inlet port **60,160** toward the outlet port **62,162**. The coal rope-breaking vane **56** is pivotable about an axis to adjust an angle of the vanes relative to a stream of air and pulverized solid fuel particles from the inlet port **60,160**. An adjustment bar **66** may connect to the vanes **56** and extend outward through the pipe elbow to allow the vanes **56** to be adjusted while the pulverized solid fuel particles flow through the head assembly **52**. The pipe elbow may further include inspection ports **68,168** and a removable cover **70,170**. The vanes may be attached to the removable cover **70,170** thus allowing them to be easily removed and replaced.

**27 Claims, 9 Drawing Sheets**



(51)	<b>Int. Cl.</b>		JP	S58164910	A	9/1983
	<i>F15D 1/04</i> (2006.01)		JP	S58224207	A	12/1983
(52)	<i>F23M 11/04</i> (2006.01)		JP	74409/89		5/1989
	<b>U.S. Cl.</b>		JP	H01314803	A	12/1989
	CPC ..... <i>F23D 2201/101</i> (2013.01); <i>F23D 2201/20</i>		JP	H0250011	A	2/1990
	(2013.01); <i>F23K 2203/008</i> (2013.01); <i>F23K</i>		JP	2-100034		8/1990
	<i>2203/201</i> (2013.01)		JP	S58110908	A	7/1993
			JP	9 133345		5/1997
			JP	09133345	A *	5/1997 ..... F23L 13/02
			JP	H1019207	A	1/1998
			JP	H11292283	A	10/1999
			JP	2000320807	A	11/2000
			JP	2009 162441		7/2009
(56)	<b>References Cited</b>					
	U.S. PATENT DOCUMENTS					
	4,654,001	A 3/1987 LaRue				
	4,684,155	A * 8/1987 Davis ..... 285/16				
	5,526,758	A 6/1996 Giammaruti et al.				
	5,588,380	A 12/1996 LaRose				
	5,623,884	A * 4/1997 Penterson et al. .... 110/264				
	6,053,118	A 4/2000 Okamoto et al.				
	6,058,855	A 5/2000 Ake et al.				
	6,105,516	A 8/2000 Bowen				
	6,409,790	B1 6/2002 Calderon et al.				
	2003/0209470	A1 11/2003 Wark				
	2007/0095260	A1 * 5/2007 John ..... 110/342				
	2010/0123027	A1 * 5/2010 Larue et al. .... 110/263				
	FOREIGN PATENT DOCUMENTS					
	DE	573 335 3/1933				
	DE	103 60 839 B3 6/2005				
	FR	748661 A 7/1933				
	OTHER PUBLICATIONS					
	Notice of Preliminary Rejection from the Korean Intellectual Prop-					
	erty Office dated Feb. 22, 2013 for Korean Application 10-2011-					
	7016290.					
	Office Action of the Intellectual Property Office of Taiwan dated Nov.					
	11, 2012.					
	Notice of Reasons for Rejection from the Japanese Intellectual Prop-					
	erty Office mailed Jun. 11, 2013 for JP2011-542187.					
	Japanese Office Action issued Dec. 8, 2014 for JP Appln. No. 2014-					
	20213.					
	Mexican Office Action issued Nov. 28, 2014 for MX Appln. No.					
	MX/a/2011/006410.					
	First Examination report issued by the Australian Patent Office dated					
	May 5, 2015 for Australian Patent Appln. No. 2009336102.					
	* cited by examiner					

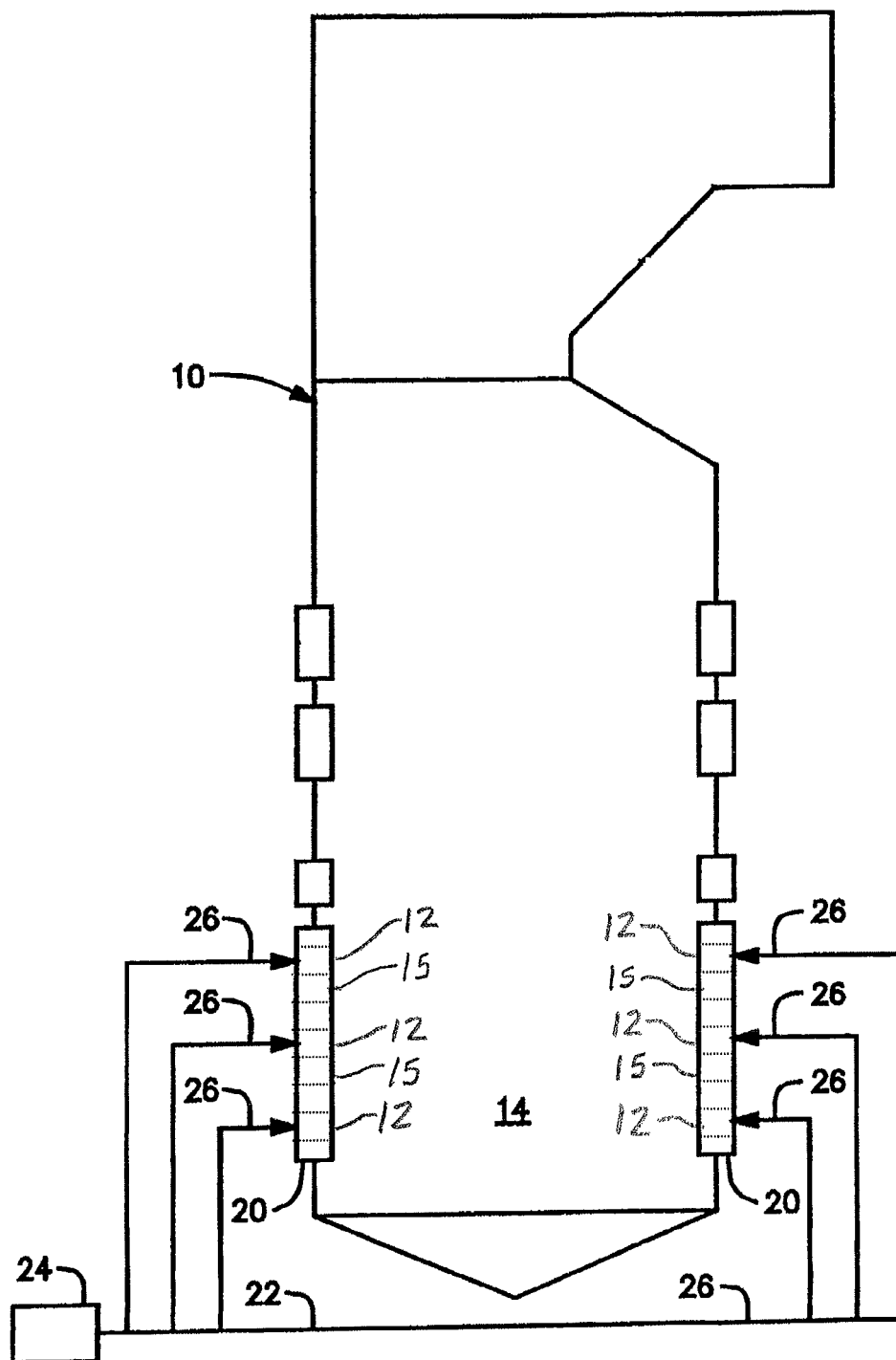


FIG. 1  
(Prior Art)

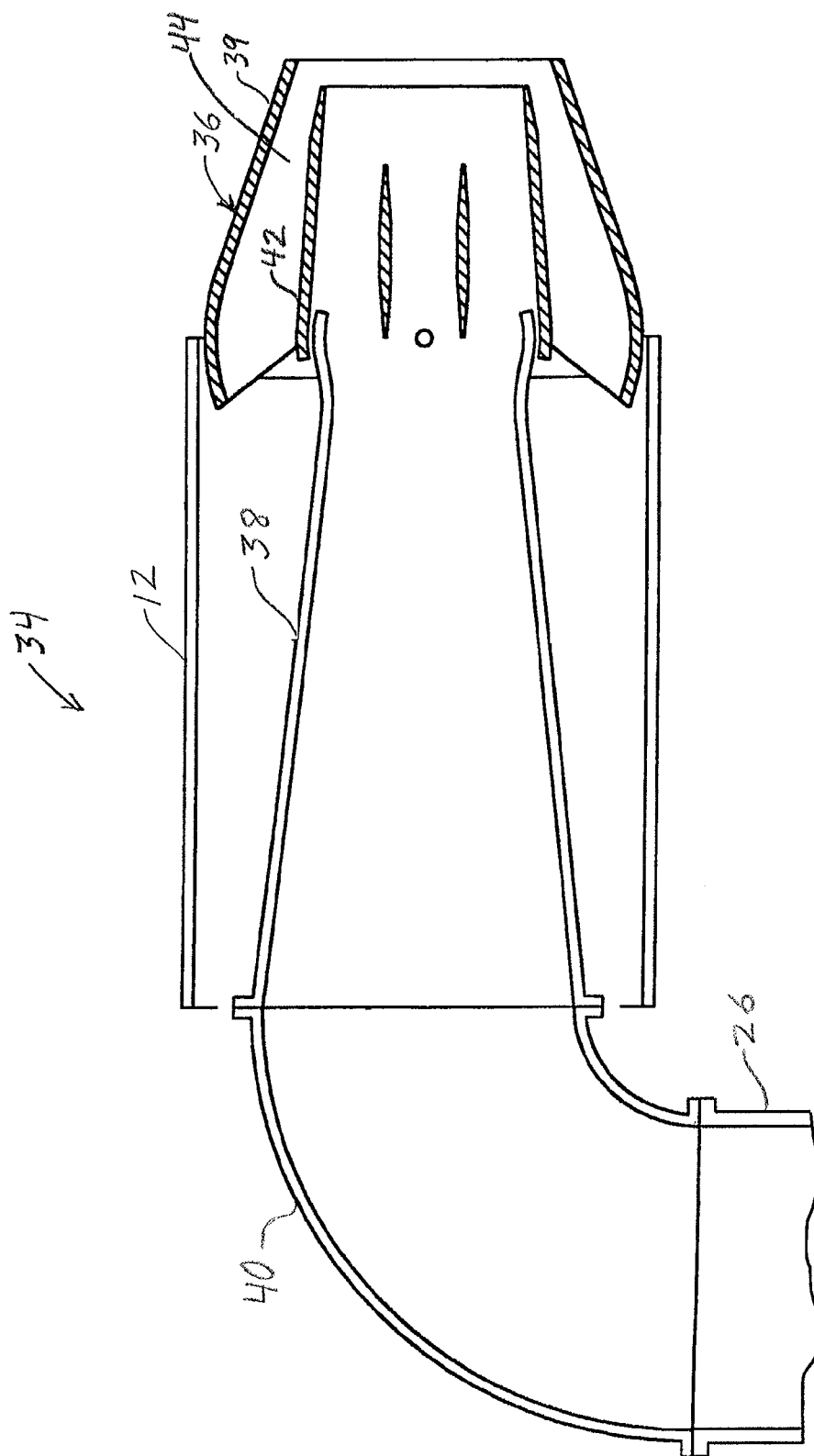


FIG. 2  
(Prior Art)

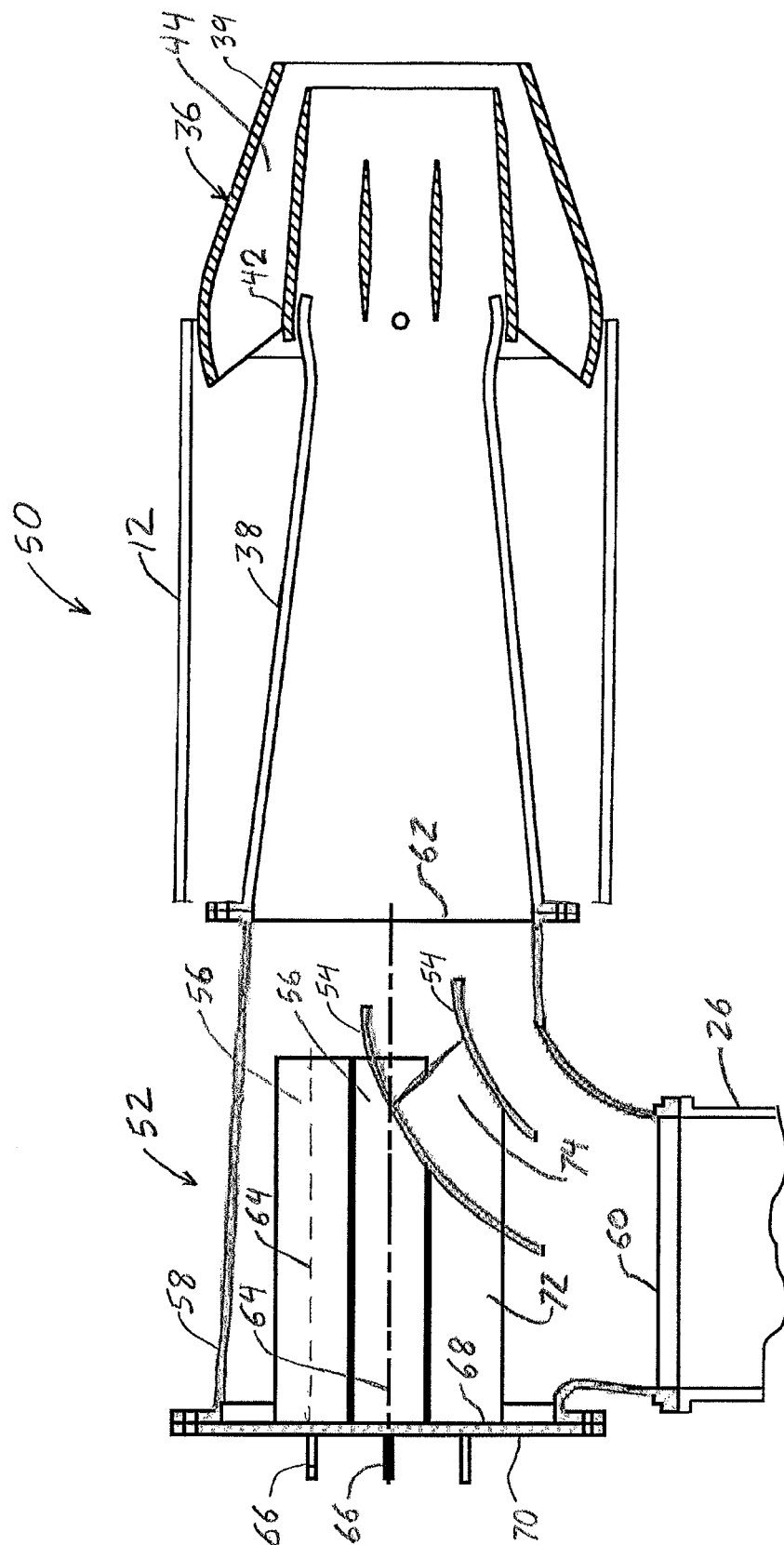


FIG. 3

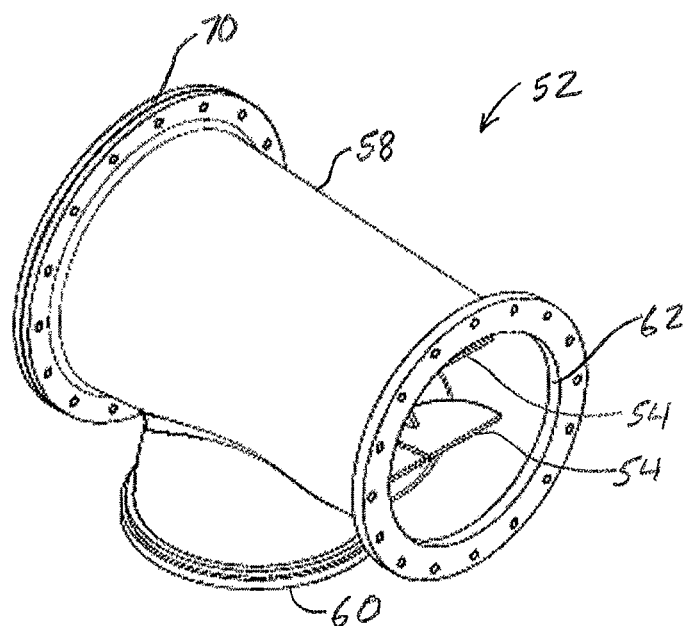


FIG. 4

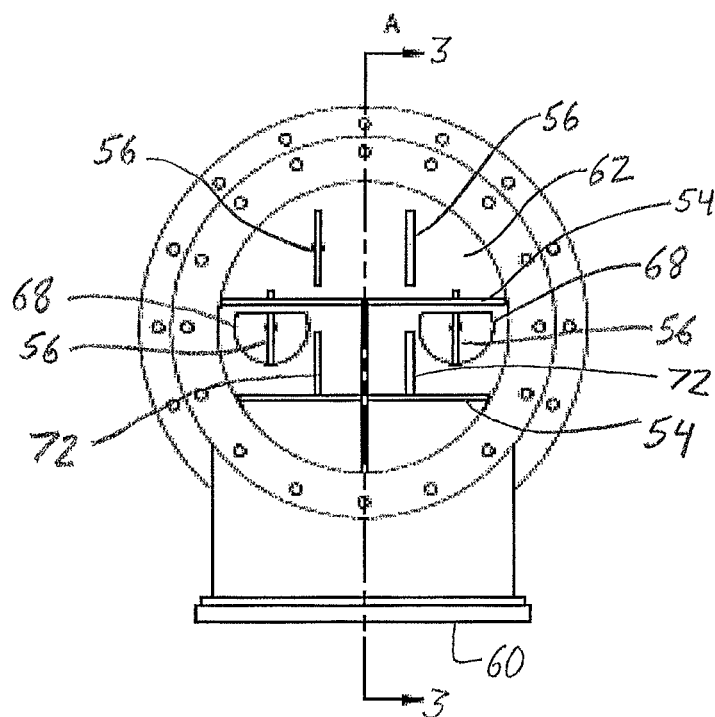


FIG. 5

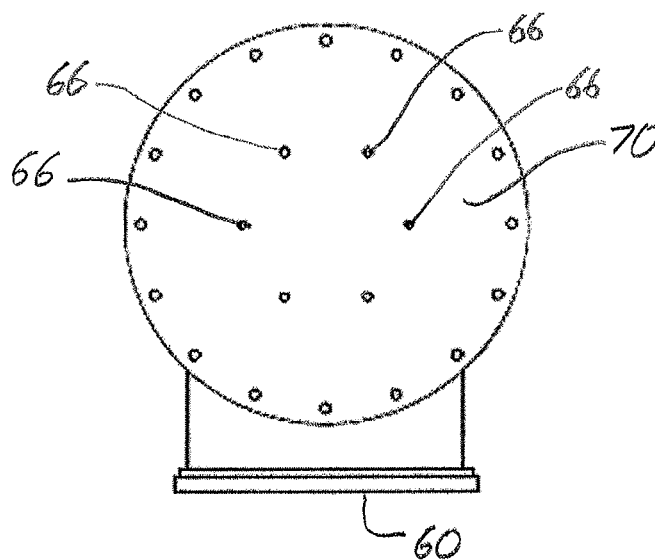


FIG. 6

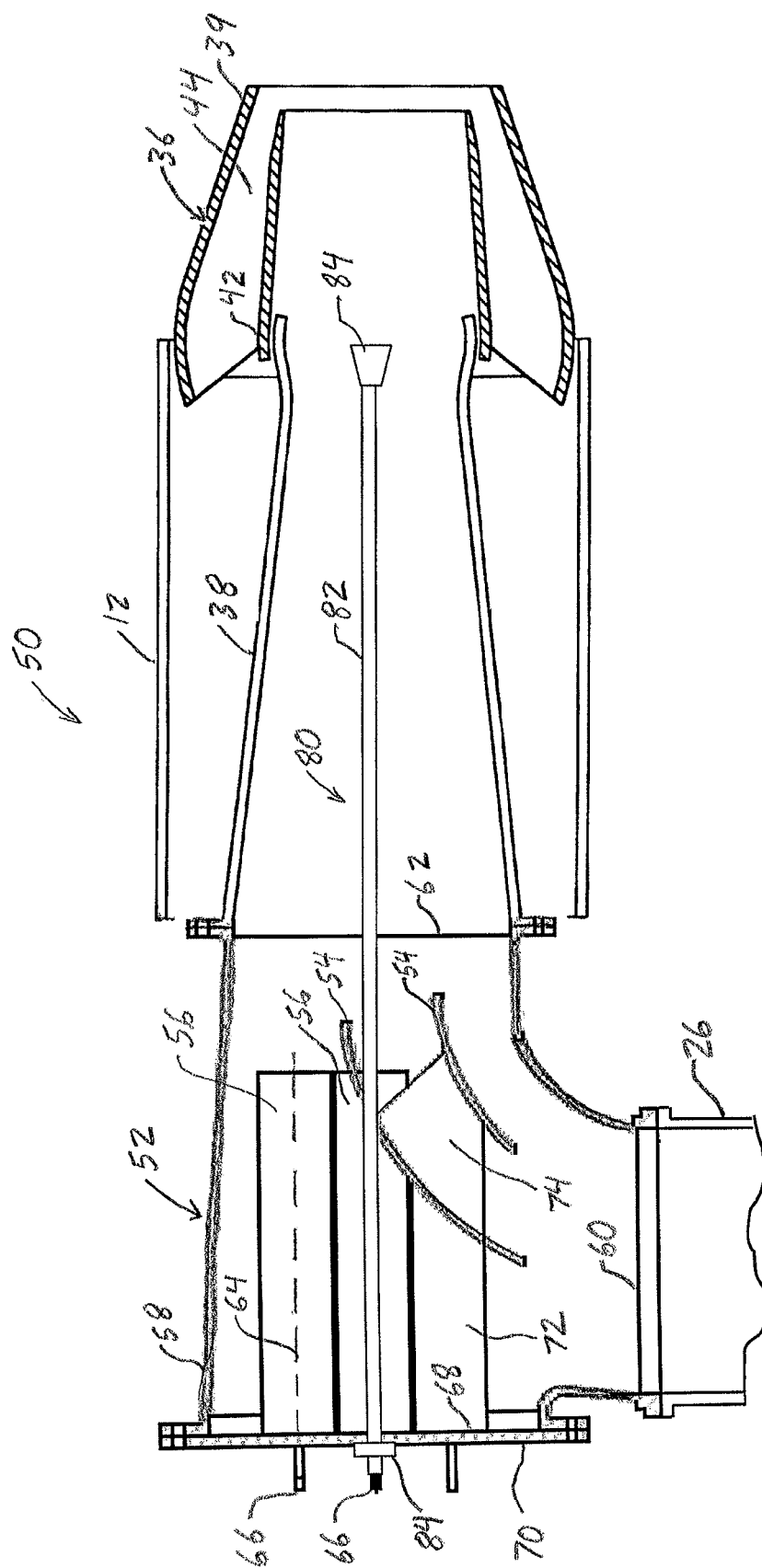


FIG. 7



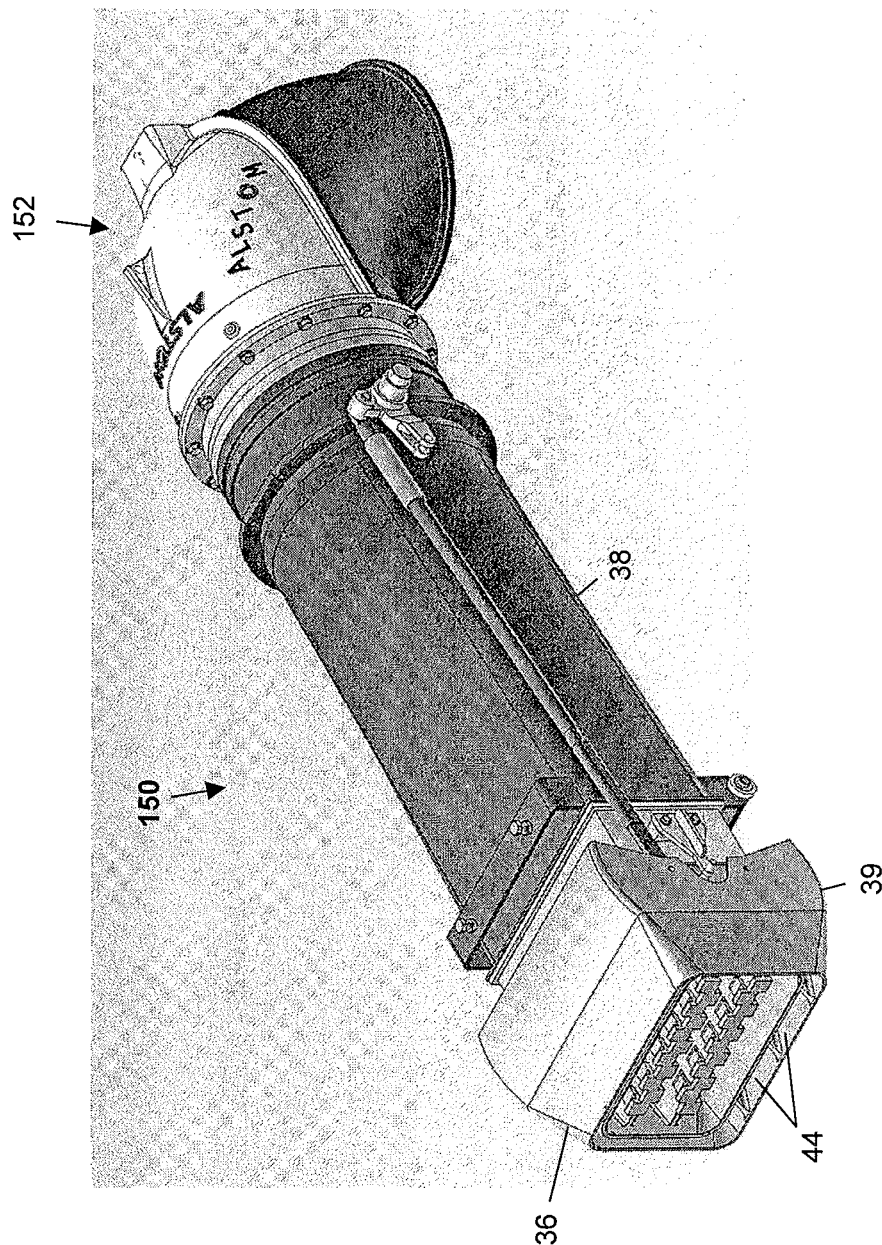


Fig. 8

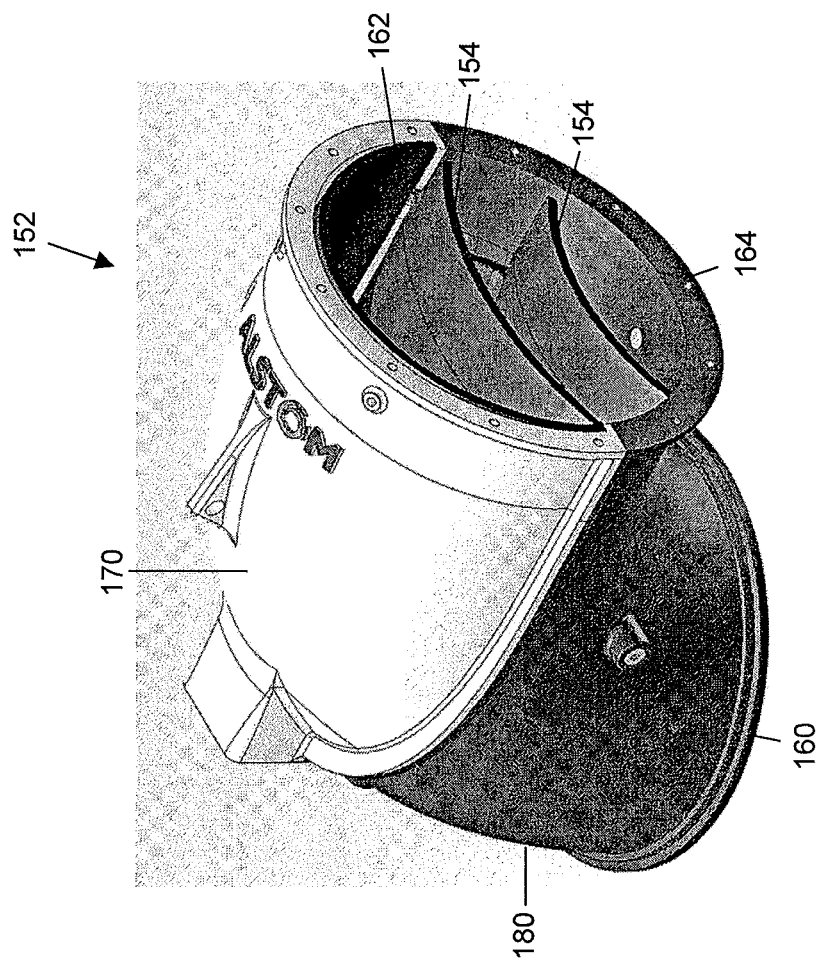


Fig. 9

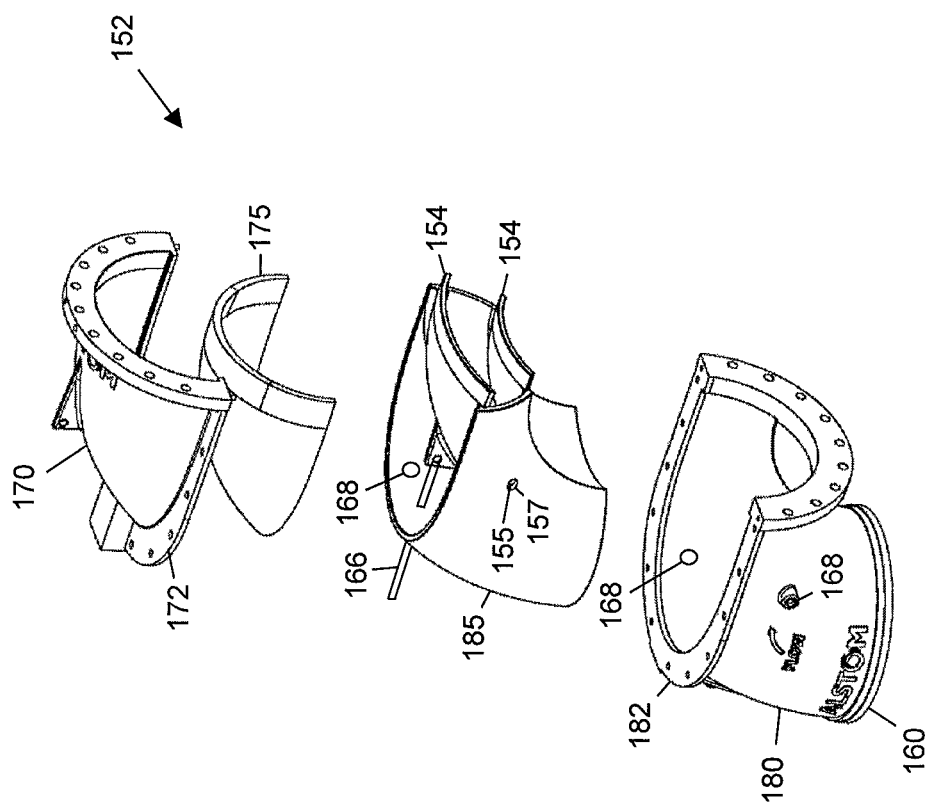


Fig. 10

# COAL ROPE DISTRIBUTOR WITH REPLACEABLE WEAR COMPONENTS

## CROSS REFERENCE TO RELATED APPLICATIONS

This application claiming priority from and the benefit and earlier filing date of U.S. Provisional Patent application 61/138,578 filed Dec. 18, 2008 entitled "Pulverized Fuel Head Assembly With Coal Rope Distributor" by Oliver G. BRIGGS, Jr., Paul M. COLSON, Christopher D. CURL, Dai Q. DAU, Wendell H. MILLS. The Provisional Patent application is hereby incorporated in its entirety.

## BACKGROUND

The present invention relates to pulverized solid fuel (pulverized coal) delivery systems and, more particularly, to a fuel head assembly for use in a pulverized coal delivery system.

FIG. 1 depicts an example of a pulverized solid fuel-fired steam generator 10, which is shown to include a combustion chamber 14 within which the combustion of pulverized solid fuel (e.g., pulverized coal) and air is initiated. Hot gases that are produced from combustion of the pulverized coal and air rise upwardly in the steam generator 10 and give up heat to fluid passing through tubes (not shown) that in conventional fashion line the walls of the steam generator 10. The steam generated in the steam generator 10 may be made to flow to a turbine (not shown), such as used in a turbine/generator set (not shown), or for any other purpose.

The steam generator 10 may include one or more windboxes 20, which may be positioned in the corners or the sides of the steam generator 10. Each windbox 20 is provided with a plurality of air compartments 15 through which air supplied from a suitable source (e.g., a fan) is injected into the combustion chamber 14 of the steam generator 10. Also disposed in each windbox 20 is a plurality of fuel compartments 12, through which pulverized coal is injected into the combustion chamber 14 of the steam generator 10.

The pulverized coal is supplied to the fuel compartments 12 by a pulverized coal supply means 22, which includes a pulverizer 24 in fluid communication with the fuel compartments 12 via a plurality of pulverized solid fuel ducts 26. The pulverizer 24 is operatively connected to an air source (e.g., a fan), whereby the air stream generated by the air source transports the pulverized coal from the pulverizer 24, through the solid fuel ducts 26, through the fuel compartments 12, and into the combustion chamber 14.

FIG. 2 depicts a cross-sectional, elevation view of a conventional pulverized coal nozzle assembly 34 disposed within a fuel compartment 12. While only one fuel compartment 12 is shown, it will be appreciated that each fuel compartment 12 of FIG. 1 may include a nozzle assembly 34. The nozzle assembly 34 includes a nozzle tip 36, which protrudes into the combustion chamber 14, a fuel feed pipe 38, which extends through the fuel compartment 12 and a head assembly 40 by which the nozzle assembly 38 is coupled to the solid fuel duct 26. Typically, the head assembly 40 comprises an elbow that connects the substantially vertical solid fuel duct 26 with the substantially horizontal fuel feed pipe 38.

The nozzle tip 36 may have a double shell configuration, comprising an outer shell 39 and an inner shell 42. The inner shell 42 is coaxially disposed within the outer shell 39 to provide an annular space 44 between the inner and outer shells 42, 39. The inner shell 42 is connected to the fuel feed pipe 38 for feeding a stream of pulverized coal entrained in air through the fuel feed pipe 38 and the inner shell 42 into the

combustion chamber 14 (FIG. 1). The annular space 44 feeds a stream of secondary air into the combustion chamber 14, which helps to cool the nozzle tip 36. While the nozzle tip 36 is shown as being separate and pivotable relative to the fuel feed pipe 38, it will be appreciated that the end of the fuel feed pipe 38 may instead be shaped to form a stationary nozzle tip.

Historically, pulverized coal boiler systems have had difficulty achieving uniform distribution of pulverized coal and transport air across the fuel duct 26 and nozzle assembly 34. Maldistribution is associated with the transport in a two phase flow system of a pulverized solid (e.g., coal) and gas (e.g., air). At each turn in the fuel duct 26, separation between the phases occurs. Finally, when the piping transitions from the vertical fuel duct 26 to horizontal nozzle assembly 34, a narrow, concentrated stream of coal, known as a "coal rope", has been established in certain portions of the cross section of the fuel feed pipe 38.

Each nozzle assembly 34 will have a different coal rope concentration and location depending on the upstream routing of the fuel duct 26 and other factors such as air and coal flow rates. This coal roping promotes localized erosion that accelerates wear and reduces component life. Coal roping also decreases the fuel/air mixing efficiency and, thus, decreases the efficiency of fuel combustion.

The coal ropes cause erosion where they contact the walls. They follow the airflow currents. In FIG. 2, the currents may cause the ropes to erode the walls of the fuel feed pipe 38. The fuel feed pipes 38 are located inside of the fuel compartments 12. These typically pass through the windbox. Therefore, it is very difficult to replace parts within the fuel feed pipe 38.

Other parts, such as the head assembly 40 are exposed and easier to access and maintain.

In the past, improving pulverized coal distribution through the horizontal nozzle assembly 34 was done with a device known as a coal rope breaker, which are typically mechanical devices disposed in the fuel feed pipe 38. For example, U.S. Pat. No. 6,105,516 describes multiple, transversely extending rib segments protruding into the fuel feed pipe portion of the nozzle, U.S. Pat. No. 5,526,758 describes a distribution half-cone mounted within a burner nozzle, and U.S. Pat. No. 5,588,380 describes a conical diffuser with angled support legs disposed along the coal nozzle axis. Another known method for breaking up coal ropes includes placing an orifice within the fuel feed pipe 38.

Experience and computer modeling has indicated that these coal rope breaking devices have had some success in redistributing the air, but little impact on the pulverized coal distribution within the nozzle. Furthermore, these coal rope-breaking devices add unwanted pressure drop to the pulverized coal delivery system. This pressure drop could have the potential of reducing or limiting the pulverizer system delivery capacity.

Thus, there is a need for a device that is easy to service and maintain that improves pulverized coal distribution through the burner nozzle assembly to eliminate or reduce the formation of coal ropes and the problems associated with coal ropes, while reducing the amount of unwanted pressure drop in the pulverized coal delivery system.

## BRIEF SUMMARY

The above-described and other drawbacks and deficiencies of the prior art are overcome or alleviated by a head assembly for a pulverized coal nozzle including at least one turning vane and at least one coal rope-breaking vane disposed within a pipe elbow. The turning vane is angled relative to the inlet port and the outlet port of the pipe elbow to redirect a stream

of air and pulverized coal particles from the inlet port toward the outlet port. The coal rope-breaking vane is pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to a stream of air and pulverized coal particles from the inlet port. A portion of the coal rope-breaking vane may extend through the pipe elbow to allow the coal rope-breaking vane to be adjusted while the pulverized coal particles flow through the head assembly. The turning vanes may also be adjustable.

In various embodiments, the pipe elbow further includes a removable cover an inspection port, and a removable cover. The at least one coal rope breaking vane and at least one turning vane may be attached to the removable cover, thus allowing the at least one turning vane and at least one coal rope breaking vane to be removed with the removable cover.

### BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like items are numbered alike in the various Figures:

FIG. 1 is a schematic depiction of a prior art coal-fired steam generator including a plurality of windboxes having fuel compartments disposed therein;

FIG. 2 is a cross-sectional, elevation view of a prior art pulverized coal nozzle assembly disposed within a fuel compartment;

FIG. 3 is a cross-sectional, elevational view of a pulverized coal nozzle assembly including a fuel head assembly in accordance with an embodiment of the present invention;

FIG. 4 is a perspective view of the fuel head assembly of FIG. 3;

FIG. 5 is an elevation view of the fuel head assembly of FIG. 3 depicting the outlet end;

FIG. 6 is an elevation view of the fuel head assembly of FIG. 3 depicting the access port cover; and

FIG. 7 is a cross-sectional, elevation view of a pulverized coal nozzle assembly in accordance with another embodiment of the present invention;

FIG. 8 is a perspective view of a another embodiment of a pulverized coal nozzle assembly according to the present invention;

FIG. 9 shows a perspective view of the fuel head assembly of FIG. 8.

FIG. 10 is an exploded view of the fuel head assembly of FIG. 9 showing internal structures.

### DETAILED DESCRIPTION

FIG. 3 depicts a cross-sectional, elevation view of a pulverized coal nozzle assembly 50 disposed within a fuel compartment 12. While only one fuel compartment 12 is shown, it will be appreciated that each fuel compartment 12 of FIG. 1 may include a nozzle assembly 50. The nozzle assembly 50 includes a nozzle tip 36, which may protrude into the combustion chamber 14, a fuel feed pipe 38, which extends through the fuel compartment 12 and a head assembly 52 by which the nozzle assembly 50 is coupled to a solid fuel duct 26.

Referring to FIGS. 3 through 6, the head assembly 52 for a pulverized solid fuel nozzle 50 includes at least one turning vane 54 and at least one coal rope breaking vane 56 disposed within a pipe elbow 58. The embodiment shown includes two turning vanes 54 and four coal rope-breaking vanes 56. The pipe elbow 58 may include, for example, a ninety degree mitered elbow that can be fit into an existing system in place of a standard elbow (e.g. head assembly 40 of FIG. 2). Each turning vane 54 is angled relative to an inlet port 60 and an

outlet port 62 of the pipe elbow 58 to redirect a stream of air and pulverized coal particles from the inlet port 60 toward the outlet port 62, which helps to promote flow and reduce pressure drop. In the example shown, the turning vanes 54 are bent to form a radius, and extends substantially across the entire flow area of the pipe elbow 58. Each turning vane 54 may be severed, as indicated at 59, to allow the left and right sides of the turning vanes, as shown in FIG. 5, to be independently adjusted, as will be discussed in further detail hereinafter. The turning vanes 54 may be made from abrasion resistant metals or ceramics.

Each coal rope-breaking vane 56 is pivotable about an axis 64 to adjust an angle of the coal rope-breaking vane 56 relative to a stream of air and pulverized coal particles from the inlet port 60. A portion 66 of the coal rope-breaking vane 56 may extend through the pipe elbow 58 to allow the coal rope-breaking vane 56 to be adjusted while the pulverized coal particles flow through the head assembly 52. This allows for easy, on-line adjustment of the coal rope breaking vanes 56 to account for differences in coal rope concentration and location among the nozzle assemblies 50 in a boiler. Depending on the length of the coal rope breaking vanes 56, the turning vanes 54 may include inspection ports 68 (FIG. 5) through which the coal rope breaking vanes 56 extend. The coal rope breaking vanes 56 may be made from abrasion resistant metals or ceramics.

The pipe elbow 58 may further include an inspection port 68 and a removable cover 70. The coal rope breaking vanes 56 and turning vanes 54 may be attached to the removable cover 70, thus allowing them to be easily removed by simply removing the cover 70. Access to the windbox or furnace is not required. Once removed, the cover 70, and vanes 54, 56 can be shipped as an assembly for off-site repair and refurbishment. Replacing burner head 52 components extends the wear life of larger stationary nozzles and tips.

In the embodiment shown, each turning vane 54 is secured to support bars 72, which is in turn are secured to the access cover 70. One or more spacers 74 may be secured between the turning vanes 54 for added structural stability. The support bars 72 may include a portion (e.g., a pin) 76 that extends through the removable cover 70 to secure the support bars 72 to the cover 70 and allow the turning vanes 54 to be adjusted without removing the cover 70. Each support bar 76 is pivotable about an axis 78 to adjust an angle of the turning vanes 54 secured to the support bar 76 relative to a stream of air and pulverized coal particles from the inlet port 60. The support bars 72 may be secured in place by lock nuts or the like, which can be threaded on the external portions 76.

The coal rope breaking vanes 56 may include a portion (e.g., pin) 66 that extends through the removable cover 70 to secure the coal rope breaking vanes 56 to the cover 70 and to allow the coal rope breaking vanes 56 to be adjusted without removing the cover 70. The coal rope breaking vanes 56 may be secured in place by lock nuts or the like, which can be threaded on the external portion 66. In the embodiment shown, the coal rope breaking vanes 56 and turning vanes 54 are not secured to the pipe elbow 58 other than by the cover 70, thus allowing them to be removed from the pipe elbow 58 with the cover 70.

Computer modeling has shown that the fuel head assembly 52 of the present invention improves coal distribution within the nozzle assembly 50, while maintaining substantially the same pressure loss as in a standard, long-radius pipe elbow (e.g., head 40 in FIG. 1). While not wanting to be bound by theory, it is believed that the improvement in coal distribution within the nozzle assembly 50 is partly due to the ability of the coal rope breaking vanes 56 to be positioned, and thus tai-

5

lored, to the coal roping conditions within a particular nozzle assembly 50. Furthermore, it is believed that the improvement in coal distribution within the nozzle 50 is partly due to the location of coal rope breaking vanes 56, which are upstream of the fuel feed pipe 38, where prior art coal rope breaking devices are typically located. By placing the coal rope breaking vanes 56 in the fuel head assembly 52, the effective length available to allow coal particles to evenly distribute in the nozzle assembly 50 is increased.

Thus, when compared to the prior art coal rope breaking devices, the head assembly 52 of the present invention provides improved pulverized coal distribution through the horizontal burner nozzle assembly 50 to eliminate or reduce the formation of coal ropes and the problems associated with coal ropes, while reducing the amount of unwanted pressure drop.

The nozzle tip 36 may have a double shell configuration, comprising an outer shell 39 and an inner shell 42. The inner shell 42 is coaxially disposed within the outer shell 39 to provide an annular space 44 between the inner and outer shells 42, 39. The inner shell 42 is connected to the fuel feed pipe 38 for feeding a stream of pulverized coal entrained in air through the fuel feed pipe 38 and the inner shell 42 into the combustion chamber 14 (FIG. 1). The annular space 44 feeds a stream of secondary air into the combustion chamber 14, which helps to cool the nozzle tip 36. While the nozzle tip 36 is shown as being separate and pivotable relative to the fuel feed pipe 38, it will be appreciated that the end of the fuel feed pipe 38 may instead be shaped to form a stationary nozzle tip.

FIG. 7 depicts an embodiment of the burner nozzle assembly 50 with cylindrical geometry according to the present invention that includes a means 80 for adjusting a flame associated with the nozzle assembly 50. The adjusting means 80 allows for on-line flame shape control and provides the advantage of tailoring the flame front to maximize the reduction in boiler emissions, like NOx and CO. The adjusting means 80 includes a rod 82 extending along the central axis of the nozzle assembly 50, and a bluff body 84 (a body having a shape that produces resistance when immersed in a moving fluid) disposed at a free end of the rod 82 and positioned within the nozzle tip 36. The opposite end of the rod 82 extends through a gland seal 84 disposed through the removable cover 70. The gland seal 84 prevents the stream of pulverized coal entrained in air from escaping along the rod 82, while at the same time allowing the rod 82 to move in a direction along its axis. The rod 82 may be supported within the fuel feed pipe 38 by a pair of legs (not shown), which are fixed to the rod 82 and rest on an inner surface of the fuel feed pipe 38. Movement of the rod 82 and bluff body 84 in a direction along its axis allows the shape of the flame to be adjusted.

While FIG. 7 depicts the use of a bluff body 84, it is contemplated that other structures may be employed by the adjusting means. For example, a swirler (a body having fins spaced about its perimeter) may be used to impart rotation on the flow of pulverized coal entrained in air.

FIG. 8 is a perspective view of another embodiment of a pulverized coal nozzle assembly according to the present invention. This embodiment includes a nozzle assembly 50 and a head assembly 152. The nozzle assembly 50 has a fuel feed pipe 38, which extends through a fuel compartment 12. Each fuel compartment of FIG. 1 may contain a nozzle assembly 50.

As in the previous embodiment, the nozzle assembly 50 includes a nozzle tip 36 at one end of the fuel feed pipe 38 which may protrude into a combustion chamber 14. The other end of the fuel feed pipe 38 is connected to the head assembly 152.

6

FIG. 9 shows a perspective view of the fuel head assembly 152 of FIG. 8. The head assembly 152 has an inlet port 160, and an outlet port 162. Both of these have flanges to attach to other parts. Outlet port flange 164 is shown here which attaches the head assembly 152 to the fuel feed pipe 38.

A removable cover 170 and lower casing 180 connect to each other to provide an outer structure of head assembly 152.

Two curved vanes 154 are partially shown here. These function to guide the air/fuel particles through the head assembly 152 but also function to break up coal ropes. These have a curved shape from side to side of outlet port 162. They are also curved generally following a path toward the inlet port 160. These generally direct the fuel particles entrained in air flow around from the inlet port 160 to the outlet port 162 reducing collection of a coal rope having the largest possible radius of curvature that typically runs along the inside surface of the head assembly 152. These direct a portion of the flow underneath each of the curved vanes 154 instead of on the inner surface of the head assembly 152.

The curved vanes 154 are curved along two axes. They curve along a path from the inlet port 160 to the outlet port 162. They also may curve moving from side to side across the outlet port 162. In the preferred embodiment, the curved vanes 154 are fixed and do not move. They are shaped to keep the distribution of coal particles even and break up coal ropes.

An alternative embodiment allows the curved vanes 154 to pivot such that the front edge shown here may move upward or downward relative to the outlet port 162. Similarly, the rear edge, not shown, moves in the opposite direction. Optionally, an adjustment bar 166 is attached to at least one of the curved vanes 154 and extends out of the back of the lower casing 180 (not shown here). An operator will be allowed to interactively adjust one or more curved vanes 154 to optimize operation, and reduce the formation of coal ropes.

With reference to FIGS. 8-9, it is also possible to direct the fuel/air flow to pass down the fuel feed pipe 38 to minimize erosion and damage to the fuel feed pipe. This shifts the erosion to the curved vanes 154 and the remainder of the head assembly 152.

The curved vanes 154 and the inside of head assembly are covered with a replaceable liner that is highly wear-resistant, such as ceramic or partially metal and partially ceramic. These parts will be described in greater detail in connection with FIG. 10.

The fuel feed pipe 38 is within a fuel compartment 12 that is within the windbox. Therefore, to replace or repair the fuel feed pipe 38, one must disassemble to windbox, then the fuel compartment, then replace or repair the fuel feed pipe 38. This is time-consuming and costly.

On the other hand, the head assembly 152 extends out of the back of the windbox and is easily accessible. In addition, the combustion chamber is on the other side windbox, so the temperatures are significantly lower near the head assembly 152. This requires less time to cool down for servicing.

The embodiment of the present invention also has a removable cover 170. Removal of this cover allows easy access to the parts to be serviced. This makes it his makes it even easier to maintain.

Even though 2 curved vanes 154 are shown here, three or more vanes may be used. Optionally, the curved vanes 154 may be allowed to tilt about two axes.

FIG. 10 is an exploded view of the fuel head assembly of FIG. 9 showing internal structures. It can now be seen that once the removable cover 170 has been removed, the other parts are easily accessible.

There are replaceable internal parts that are highly wear resistant, such as a cover liner 175. This covers the inside

7

surface of the removable cover **170**. There also is a casing liner **185** that covers the inside surface of lower casing **180**. Curved vanes **154** are made of highly wear resistant materials, and are also removable and replaceable.

In the optional embodiment, the adjustment bar **166** is shown attaching to the uppermost curved vane **154**. In alternative embodiments there may be several adjustment bars for moving different turning vanes **154** or moving the curved vanes **154** about different axes.

If an alternative embodiment having moving curved vanes **154** is used, pivot pins **155** of the curved vanes **154** are used to allow the curved vanes to pivot. They fit into pivot recesses **157**.

One or more inspection ports **168** may be located in the head assembly passing through the casings and the liners to act as inspection ports. Additionally, any of the other features described in connection with FIGS. 3-7 may be employed in this embodiment. The features such as rope breaking vanes, control apparatus and supports may be added.

For reassembly, an upper flange **172** of the removable cover and the lower flange **182** of the lower casing are bolted together to sandwich a gasket (preferably made of tetrafluoro-ethylene) for a positive seal. Therefore, the present invention provides a device for breaking coal ropes that has removable wear parts, is easily accessible and less costly to maintain.

It should be understood that, unless stated otherwise herein, any of the features, characteristics, alternatives or modifications described regarding a particular embodiment herein may also be applied, used, or incorporated with any other embodiment described herein. Also, the drawings herein are not drawn to scale.

Since the invention is susceptible to various modifications and alternative forms, it should be understood that the invention is not intended to be limited to the particular forms disclosed. Rather, the scope of the invention extends to all modifications, equivalents and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

**1.** A head assembly for a pulverized coal nozzle, the head assembly comprising:

a pipe elbow including an inlet port and an outlet port;  
a turning vane disposed within the pipe elbow, the turning vane being angled relative to the inlet port and the outlet port to redirect a stream of air and pulverized coal particles from the inlet port toward the outlet port; and  
a coal rope-breaking vane disposed within the pipe elbow, the coal rope breaking vane being pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to the stream of air and pulverized coal particles from the inlet; wherein the coal rope-breaking vane is disposed above the turning vane port.

**2.** The head assembly of claim **1**, wherein a portion of the coal rope breaking vane extends through the pipe elbow to allow the coal rope breaking vane to be adjusted while the pulverized coal particles flow through the head assembly.

**3.** The head assembly of claim **1**, wherein the turning vane is pivotable to adjust an angle of the turning vane relative to the stream of air and pulverized coal particles from the inlet port.

**4.** The head assembly of claim **3**, wherein the turning vane is adjustable while the pulverized coal particles flow through the head assembly.

**5.** The head assembly of claim **1**, wherein the turning vane is one of two or more turning vanes disposed in the pipe elbow.

8

**6.** The head assembly of claim **1**, wherein the coal rope-breaking vane is one of two or more coal rope breaking vanes disposed within the pipe elbow.

**7.** The head assembly of claim **1**, wherein:

the turning vane is one of two or more turning vanes disposed in the pipe elbow; and

the coal rope-breaking vane is one of two or more coal rope breaking vanes disposed within the pipe elbow.

**8.** A head assembly for a pulverized coal nozzle, the head assembly comprising: a pipe elbow including an inlet and an outlet port; a turning vane disposed within the pipe elbow, the turning vane being angled relative to the inlet port and the outlet port to redirect a stream of air and pulverized coal particles from the inlet port toward the outlet port; and a coal rope-breaking vane disposed within the pipe elbow, the coal rope breaking vane being pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to the stream of air and pulverized coal particles from the inlet port; wherein the pipe elbow further includes:

an access port, and

a removable cover over the access port, wherein the coal rope breaking vane is pivotally attached to the removable cover.

**9.** The head assembly of claim **8**, wherein a portion of the coal rope breaking vane extends through the access port to allow the coal rope breaking vane to be adjusted while the pulverized coal particles flow through the head assembly.

**10.** The head assembly of claim **8**, wherein the turning vane is attached to the removable cover, thereby allowing the turning vane and coal rope-breaking vane to be removed with the removable cover.

**11.** The head assembly of claim **10**, further comprising:

a support vane disposed between the removable cover and the turning vane to attach the turning vane to the removable cover.

**12.** The nozzle assembly of claim **8**, wherein the coal rope-breaking vane is disposed above the turning vane.

**13.** A pulverized coal nozzle comprising:

a nozzle tip;

a head assembly; and

a fuel feed pipe extending between the nozzle tip and the head assembly, wherein the head assembly comprises:

a pipe elbow including an inlet port and an outlet port, the outlet port being coupled to the fuel feed pipe,

a turning vane disposed within the pipe elbow, the turning vane being angled relative to the inlet port and the outlet port to redirect a stream of air and pulverized coal particles from the inlet port toward the outlet port, and

a coal rope-breaking vane disposed within the pipe elbow, the coal rope breaking vane being pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to the stream of air and pulverized coal particles from the inlet port wherein the coal rope-breaking vane is disposed above the turning vane.

**14.** The pulverized coal nozzle of claim **13**, wherein a portion of the coal rope breaking vane extends through the pipe elbow to allow the coal rope breaking vane to be adjusted while the pulverized coal particles flow through the head assembly.

**15.** The pulverized coal nozzle of claim **13**, wherein the turning vane is one of two or more turning vanes disposed in the pipe elbow.

**16.** The pulverized coal nozzle of claim **13**, wherein the coal rope breaking vane is one of two or more coal rope breaking vanes disposed within the pipe elbow.

9

17. The pulverized coal nozzle of claim 13, wherein:

the turning vane is one of two or more turning vanes disposed in the pipe elbow; and

the coal rope-breaking vane is one of two or more coal rope breaking vanes disposed within the pipe elbow.

18. The pulverized coal nozzle of claim 13, wherein an end of the fuel feed pipe forms the nozzle tip.

19. The pulverized coal nozzle of claim 12, further comprising:

a means for adjusting a flame associated with the nozzle assembly, the means including a rod extending through the head assembly and along a centerline of the fuel feed pipe.

20. The pulverized coal nozzle of claim 13, wherein the turning vane is pivotable to adjust an angle of the turning vane relative to the stream of air and pulverized coal particles from the inlet port.

21. The pulverized coal nozzle of claim 13, wherein the turning vane is adjustable while the pulverized coal particles flow through the head assembly.

22. A head assembly for a pulverized coal nozzle, the head assembly comprising: a pipe elbow including an inlet and an outlet port; a turning vane disposed within the pipe elbow, the turning vane being angled relative to the inlet port and the outlet port to redirect a stream of air and pulverized coal particles from the inlet port toward the outlet port; and a coal rope-breaking vane disposed within the pipe elbow, the coal rope breaking vane being pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to the stream of air and pulverized coal particles from the inlet port wherein the pipe elbow further includes:

10

an access port, and

a removable cover over the access port, wherein the coal rope breaking vane is pivotally attached to the removable cover.

23. The pulverized coal nozzle of claim 22, wherein a portion of the coal rope breaking vane extends through the access port to allow the coal rope breaking vane to be adjusted while the pulverized coal particles flow through the head assembly.

24. The pulverized coal nozzle of claim 22, wherein the turning vane is attached to the removable cover, thereby allowing the turning vane and coal rope breaking vane to be removed with the removable cover.

25. The pulverized coal nozzle of claim 24, further comprising:

a support vane disposed between the removable cover and the turning vane to attach the turning vane to the removable cover.

26. A head assembly for a pulverized coal nozzle, the head assembly comprising:

a pipe elbow including an inlet port and an outlet port; a turning vane disposed within the pipe elbow, the turning vane being angled relative to the inlet port and the outlet port to redirect a stream of air and pulverized coal particles from the inlet port toward the outlet port; and

a coal rope-breaking vane disposed within the pipe elbow and extending inwardly from the inner surface of the outer portion of the pipe elbow, the coal rope-breaking vane being pivotable about an axis to adjust an angle of the coal rope-breaking vane relative to the stream of air and pulverized coal particles from the inlet port.

27. The nozzle assembly of claim 1, wherein the pivotable axis of the coal rope-breaking vane generally extends in the direction of the outlet port.

\* \* \* \* \*